

LETTER REPORT

TECHNICAL EVALUATION OF THE TAN OU 1-07B
RI/FS AND PROPOSED PLAN

Prepared for:

EG&G Idaho, Inc.
1955 Fremont Avenue
P.O. Box 1625
Idaho Falls, Idaho 83415-3932

Prepared by:

GeoTrans, Inc.
46050 Manekin Plaza, Suite 100
Sterling, Virginia 20166

November 30, 1993

1 INTRODUCTION

A review was conducted of the following documents:

- Kaminsky, J.F., K.N. Keck, A.L. Schafer-Perini, C.F. Hersley, R.P. Smith, G.J. Stormberg, and A.H. Wylie, 1993. *Remedial Investigation Final Report with Addenda for the Test Area North Groundwater Operable Unit 1-07B at the Idaho National Engineering Laboratory* (EGG-ER-10643, Revision 0), prepared by Idaho National Engineering Laboratory, EG&G Idaho, Inc. (September).
- Dunnivant, F.M., G.J. Stormberg, A.H. Wylie, C.M. Hamel, and C.A. Leon, 1993. *Feasibility Study Report for Test Area North Groundwater Operable Unit 1-07B at the Idaho National Engineering Laboratory (Draft)* (EGG-ER-10802, Rev. 1), prepared by Idaho National Engineering Laboratory, EG&G Idaho, Inc. (September).

The material in these reports was supplemented with additional information on the recently drilled wells TAN-25 and TAN-26.

The review focused on adequacy of data, interpretation of data, and the remedial action selection process. Comments and observations are provided in the following sections: (1) review of remedial investigation, (2) completeness of alternative remedial actions, (3) adequacy and completeness of the screening process, and (4) appropriateness and feasibility of selected alternative.

2 REVIEW OF REMEDIAL INVESTIGATION

In general, the data collected and data interpretation presented in the RI are adequate and appropriate, respectively. Conclusions and supporting evidence are as follows:

1. The primary source is the TSF-05 injection well. This is based on the historical use of the well (see Appendix A), groundwater sampling, and sludge sampling within the well. Other sources or potential sources are not primary based on groundwater sampling

and soil gas surveys. Another potential source includes the WRRTF injection well (WRRTF-05).

2. The primary contaminant of concern is trichloroethylene (TCE). This is based on the historical uses, groundwater sampling, and sludge sampling within the well. It also is based on toxicity characteristics of TCE. Other contaminants of potential concern include: tetrachloroethylene (PCE), cis-/trans-1,2-dichloroethylene (cis-/trans-1,2-DCE), tritium, strontium-90, and cesium-137.
3. The water table is deep and the aquifer complex. The water table at the TSF-05 injection well is approximately 200 ft below land surface. Groundwater occurs in the heterogeneous and anisotropic fractured basalt of the Snake River Plain Aquifer. The aquifer is conceptualized as a macroporous medium. Flow paths at TAN probably consist of interconnected fracture zones, rubble zones, and flow tops.
4. Below the injection zone, the Q-R interbed acts as a confining bed. This is based on water-level data that indicate a lack of hydraulic communication above and below the Q-R interbed. It is also based on existing water quality data that show no volatile organic contamination above the TCE maximum contaminant level (MCL) of 5 ug/l below the Q-R interbed.
5. As a secondary source, dense nonaqueous phase liquid (DNAPL) TCE is present in the vicinity of the TSF-05 injection well. This is based on the historical use of the well and the following indirect evidence:
 - Sludge samples from the well had TCE concentrations of 30,000 mg/kg. NAPL presence may be inferred where NAPL chemical concentrations in soil (or sludge) exceed 10,000 mg/kg (>1% of soil mass) (Cohen and Mercer, 1993, p. 9-45).

- Groundwater TCE concentrations at the well head ranged from 16 to 28 mg/l (EG&G) to 35 mg/l (USGS). Using the aqueous solubility of TCE (1,100 mg/l), these concentrations are 1.45%, 2.55%, and 3.18%, respectively, of the aqueous solubility. NAPL presence may be inferred where groundwater concentrations exceed 1% of the pure phase or effective aqueous solubility of a NAPL chemical (Cohen and Mercer, 1993, p. 9-45).
 - Mass-in-place calculations that show that TCE dissolved mass only accounts for a small percentage of the total potential mass of TCE that may have been injected.
 - Dissolved concentrations are highest near the injection well even though 20 years have passed since the last TCE was injected. With no sorption and a groundwater velocity of 0.43 ft/d, groundwater and advected contaminants should have moved over 3000 feet away from TSF-05 in 20 years.
6. The exact locations and potential extent of the DNAPL TCE is unknown. DNAPL TCE near the injection well will remain at residual saturation as disconnected blobs and ganglia. The injection zone was above the Q-R interbed, which acts as a confining bed. If sufficient volume of TCE was injected, DNAPL TCE may have migrated downward, spreading due to heterogeneities in the basalt. As a result, DNAPL may have pooled where there are flow tops/rubble zones. The presence of DNAPL TCE near the injection well is supported by TCE concentration at monitor well TAN-25 drilled 25 feet downgradient from TSF-05 injection well. The concentration was 17 mg/l (1.55% solubility). TAN-25 is screened within the injection zone of TSF-05. TAN-26 was drilled 50 feet downgradient from TSF-05 and screened near the top of the Q-R interbed. TCE concentration from this well was lower (0.67 mg/l). The low concentration in TAN-26 may indicate relatively low concentration with depth, and would correspond to or result

from the following: (1) low hydraulic conductivity of basalt 30-40 ft above the top of the QR interbed, (2) low gamma log readings with depth, perhaps corresponding to a lack of significant contamination, and/or (3) an 80-ft screen interval.

7. The current flow system is fairly well understood. The regional horizontal hydraulic gradient is southerly; the local horizontal hydraulic gradient is generally toward the southeast with a relatively flat water table in the vicinity of the TSF-05 injection well. An average groundwater velocity of 0.43 ft/d was determined based on water quality data. This is consistent with groundwater velocities determined from Darcy's equation and hydraulic conductivity data determined from hydraulic testing. The vertical hydraulic gradient is downward across the Q-R interbed. It was not possible to estimate the flow system when TSF-05 was in use.
8. The dissolved TCE plume is fairly well defined and is consistent with the groundwater flow system. The dissolved TCE plume appears to be migrating in a southeasterly direction with the leading edge defined by wells GIN-2, GIN-4, TAN-24A, and ANP-8. The vertical extent of migration appears to be limited by the Q-R interbed. These observations are consistent with the hydrogeology.

3 COMPLETENESS OF ALTERNATIVE REMEDIAL ACTIONS

It is common at DNAPL sites to divide the contamination into a dissolved contamination zone and a DNAPL zone (Cohen and Mercer, 1993, p. 9-2). The TAN RI/FS is consistent with this approach, having divided the remedial action objectives (RAOs) into two sets: (1) one for the highly contaminated zone (DNAPL zone or "hotspot") and (2) one for the dissolved TCE groundwater plume. The DNAPL zone RAO to contain and/or remediate is consistent with other DNAPL sites. The RAO for the dissolved TCE plume to restore groundwater also is consistent with other sites.

The remediation problem associated with the TSF-05 injection well is representative of the most difficult restoration problems facing scientists and engineers. This is based on a study currently being conducted on groundwater remediation by the Water Science & Technology Board of the National Research Council. This remediation is difficult because: (1) it involves DNAPL, (2) the DNAPL is in a heterogeneous fractured rock, (3) the contamination is at depth (>200 ft), (4) the DNAPL volume could be large (possibly as much as 35,000 gal), and (5) the DNAPL has been in the subsurface for a long time (perhaps as long as 35 years), allowing chemical diffusion into low flow (low hydraulic conductivity) zones. A workshop of DNAPL experts convened by the U.S. EPA concluded that there are no proven restoration technologies for this type of subsurface contamination (U.S. EPA, 1992, p. 2)

The list of potential alternative remedial actions as presented in Figure 2-1 of the draft FS is basically complete. Emphasis in this review was on subsurface technologies and not treatment technologies used at the surface. The list in Figure 2-1 was compared with Table 6-1 in Cohen and Mercer (1993), which lists remedial options potentially applicable to DNAPL contaminated sites and is based on the U.S. EPA workshop. In very general terms, some form of pump and treat is potentially applicable to the dissolved plume whereas hydraulic containment or a technology based on enhanced oil recovery (EOR) technologies is potentially applicable to the DNAPL zone.

4 ADEQUACY AND COMPLETENESS OF THE SCREENING PROCESS

The screening process appears to be inconsistent. Referring to Figure 2-1 in the draft FS, for product recovery, the screening comment is "Probably not applicable because the exact nature, location, and extent of DNAPL contamination is unknown." Based on the RI, this statement is correct. Again referring to Figure 2-1, for in situ bioremediation (nutrient injection), the screening comment is "Not feasible because of fractured, unconsolidated basalt matrix. Nutrients could not be uniformly delivered throughout the contaminated volume..." This point is made again in Table 2-2 of the FS for in situ chemical oxidation, "Unreliable because

of complex aquifer hydraulics." Based on the RI, these statements also are correct. The inconsistency is as follows. If the exact location and extent of the DNAPL is not known and media heterogeneities prohibit a uniform and reliable subsurface delivery system, how did Alternative 3 - steam-enhanced extraction, and Alternative 4 - surfactant flooding pass the screening process? It is likely that these innovative (not proven) alternatives also will fail to achieve restoration, and additional discussion is provided below.

First, for effectiveness evaluation, a 50-ft radius perimeter of TSF-05 injection well is used. Justification for this radius is unclear. Presumably, it is because of the low TCE concentration in monitor well TAN-26 located 50 feet from TSF-05. Because of the heterogeneous and fractured nature of the basalt, there is no guarantee that DNAPL is contained within 50 feet of TSF-05 in every direction. Because the exact location (and extent) of DNAPL is not known and hydraulic control is difficult, most EOR methods applied to the DNAPL zone risk mobilizing DNAPL, not controlling flow, and potentially worsening the contamination problem. Using surfactants to enhance solubilization is less likely to create this problem than EOR methods. This DNAPL mobilization could be lateral (especially due to proposed injection wells at the 50-ft radius) and, more importantly, vertical. For example, a decrease in interfacial tension and viscosity combined with the pressure increase as a result of steam flooding could potentially cause downward DNAPL migration through the Q-R interbed. Also, any DNAPL outside the 50-ft radius would not be contained, unless the wells at the 50-ft radius are extraction wells.

Second, even if DNAPL flow were controlled, EOR methods do not remove all residual DNAPL. This is contrary to the FS effectiveness evaluation that indicates the secondary source of TCE would be removed within 2 to 18 years. I believe this time estimate may be optimistic, however, I am unaware of an EOR method being applied for this length of time. Laboratory studies and small-scale field experiments are likely to yield over-optimistic expectations (Mackay and Cherry, 1989). According to Mercer and Cohen (1990), primary recovery of product typically removes 30-50% of the NAPL. Secondary and tertiary recovery, such as EOR, if successful, may remove only an additional 30-50%. Thus, as much as 10-40% of the NAPL can

remain in the subsurface after successful application of EOR methods. This is illustrated further at a DNAPL site where chemically enhanced in situ soil washing was applied (Sale et al., 1989). For this shallow, porous media site, percent concentrations of residual oil typically persisted after the soil washing was complete. Therefore, even after a successful EOR application to TSF-05, residual DNAPL would likely exist and some form of hydraulic containment may be required.

Using surfactants to enhance solubilization is most likely the technology that has the best chance of success. As pointed out by Jackson et al. (1993), "It should be appreciated, however, that problems due to geological heterogeneity will no doubt hinder restoration of DNAPL-contaminated systems undergoing surfactant-enhanced aquifer remediation (Mackay and Cherry, 1989)." Surfactant enhanced mobilization has only been used at two field trials: (1) Borden Canadian Forces Base and (2) Corpus Christi, TX (Fountain and Waddell-Sheets, 1993). Both of these sites had relatively shallow applications of the surfactant in sandy aquifers. Based on core data, "Cleaning was incomplete at both sites as evidenced by the DNAPL remaining in low hydraulic conductivity zones present at both sites" (Fountain and Waddell-Sheets, 1993). Thus, depending on the amount and behavior of the remaining DNAPL, and depending on the acceptable dissolved concentration based on a risk assessment, even this technology could require subsequent hydraulic containment.

5 APPROPRIATENESS AND FEASIBILITY OF SELECTED ALTERNATIVE

The interim action (IA) to begin in early 1994 of removing and treating contaminated groundwater in the immediate vicinity of the TSF-05 injection well is a good idea. The IA should include water-level monitoring at TAN-25 and -26, and water quality monitoring at all three wells. Data from this IA can be used in the final remedial design.

Steam-enhanced extraction and surfactant flooding (less so) likely are not appropriate because of the risk of mobilizing and not controlling DNAPL migration. Further, it is likely that these or other EOR methods will not remove all residual DNAPL and subsequent hydraulic containment may be required. As a result, Alternative 2 - conventional extraction/treatment

of groundwater at hot spot should not be eliminated. Because it appears that hydraulic containment will need to be used regardless of whether an EOR method is used first, it is logical to eliminate the risk of EOR and just use hydraulic containment. Thus, hydraulic containment (not restoration) at the hot spot appears to be the most feasible remedial alternative. Results from the IA will be helpful for the final design. Unfortunately, hydraulic containment will likely be required for a long period (beyond the year 2040), unless a new technology is developed in the near term to deal with TSF-05 contamination problem. The goal should be to minimize pumpage sufficient to maintain an inward hydraulic gradient around the DNAPL zone.

In terms of the dissolved plume, pump-and-treat technology should effectively restore that portion of the aquifer that the risk assessment deems necessary. To reduce treatment costs, as the down-hydraulic-gradient portion of the plume is remediated, the extraction wells in the restored portion of the plume can be eliminated. Restoration will likely be defined by an appropriate alternate concentration limit (ACL) as opposed to a MCL. Down-gradient extraction wells can be eliminated over time, "marching" back toward the TSF-05 injection well. Ultimately, only the hydraulic containment well(s) at or near TSF-05 will need to be pumped.

Although pump-and-treat methods will likely effectively clean up part or all of the dissolved plume, based on the final risk assessment, such a cleanup may not be necessary. If hydraulic control of the DNAPL plume is achieved, the long-term risk associated with the dissolved plume may be acceptable. For example, at the Hyde Park Landfill in Niagara Falls, NY, based on a risk assessment at this DNAPL site, a remedy was selected that provided hydraulic control of the DNAPL plume and only a small area of the dissolved plume (1985 Affidavit of Charles R. Faust, United States of America, et al. v. Hooker Chemicals and Plastics Corporation). Thus, for this fractured bedrock aquifer, the dissolved plume was not totally addressed and containment at the landfill was the selected remedy. For TAN, hydraulic containment at TSF-05 may be all that is necessary.

REFERENCES

- Cohen, R.M. and J.W. Mercer, 1993. *DNAPL Site Evaluation*, C.K. Smoley, Boca Raton, FL.
- Fountain, J.C. and C. Waddell-Sheets, 1993. Surfactant-enhanced remediation of DNAPL-contaminated aquifers, Presented paper?
- Jackson, R.E., J.F. Pickens, and A. Haug, 1993. The DNAPL problem: Locating, characterizing, and remediating DNAPL zones in ground-water systems, Presented at HAZMAT Southwest Conference, Dallas, TX (September 28-30).
- Mackay, D.M. and J.A. Cherry, 1989. Groundwater contamination: Pump-and-treat remediation, *Environmental Science and Technology*, 23(6):62-636.
- Mercer, J.W. and R.M. Cohen, 1990. A review of immiscible fluid in the subsurface: Properties, models, characterization and remediation, *Journal of Contaminant Hydrology*, 6:107-163.
- Sale, T.C., K. Piontek, and M. Pitts, 1989. Chemically enhanced in situ soil washing, in *Proceedings of Petroleum Hydrocarbons and Organic Chemicals in Ground Water*, NWWA, pp. 487-503.
- U.S. Environmental Protection Agency, 1992. Dense nonaqueous phase liquids - A workshop summary, Dallas, TX (April 16-18, 1991), EPA/600/R-92/030, ORD, Washington, DC.

APPENDIX A - Brief Site History

GeoTrans, inc.

Brief Site History

DATE	EVENT
1953	TSF-05 injection well drilled to a depth of 305 feet. It is a 12-in diameter well with perforations from 180-244 ft and 269-305 ft.
1955-1972	TSF-05 used to dispose TAN liquid wastes and concentrated evaporator sludges. It is estimated that as much as 35,000 gal of TCE may have been disposed to the well.
September 1972	The well was last used as a primary disposal site.
Early 1980s	Until the early 1980s, the well may have been used for overflow from the sump at TAN-655.
August 1987	Volatile organic compounds detected in TAN-1 and -2 drinking water wells.
Early 1989	Air sparger added to TAN water supply system.
1989	Monitor wells TAN-3, -4, -5, -8, -9, -10 (destroyed), -10A, and -11, and corehole TAN-CH1 drilled.
November 15, 1989	INEL added to NPL.
January/February 1990	Removed process sludge from the bottom 55 ft of the TSF-05 injection well.
1990	Monitor wells TAN-6, -7, -12, -13 (dry), -13A, -14, -15, and -16, and corehole TAN-CH2 drilled.
1991	RFI replaced by a RI/FS.
1992	Monitor wells TAN-18, -19, -20, -21, -22 (abandoned), -22A, -23 (abandoned), -23A, -24 (abandoned), and -24A drilled
1993	Monitor wells TAN-25 and -26 drilled